

CLAIMS

What is claimed is:

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2 1. An optical node for an optical network transporting an optical datastream,  
3 the node comprising:  
4 at least one port for optically coupling the node to at least one neighboring node;  
5 a fault restoration element to adjust the operation of the node in response to a  
6 fault;  
7 at least one optical sensor for measuring a first set of optical characteristics of the  
8 optical datastream at the node;  
9 a signal sensor configured to receive a second set of optical characteristics of the  
10 optical datastream from an upstream optical device; and  
11 a local controller configured to activate the fault restoration element if the first  
12 and second set of optical characteristics have values corresponding to a potential fault  
requiring activation of the fault restoration element.

1 2. The node of Claim 1, wherein said controller is a microprocessor having a  
2 software program residing on the microprocessor, the software program including a list  
3 of possible faults and corresponding restoration actions as a function of the first and  
4 second set of optical characteristics.

1 3. The node of Claim 2, wherein said software program records the result of  
2 the restoration instance and communicates the result of the restoration instance to the  
3 optical network.

1           4.     The node of Claim 2, wherein said software program communicates a  
2     message alerting other nodes of optical network of an upcoming restoration instance prior  
3     to the restoration instance.

1           5.       The node of Claim 2, wherein said software program includes a list of  
2   internal components likely to have failed as a function of said first and second set of  
3   optical characteristics, said software program preparing a list of components likely to  
4   have failed for each restoration instance.

1           6.       The node of Claim 1, wherein said restoration element is selected from the  
2   group consisting of: a line switcher, a redundant electrical element, and a redundant  
3   electro-optical element.

1           7.     The node of Claim 1, wherein said upstream device is an optical spectrum  
2 analyzer.

1           8.     The node of Claim 1, wherein said upstream device is an upstream node  
2     having a least one optical sensor residing in the upstream node.

1           9.       The node of Claim 8, wherein the signal sensor is an optical receiver for  
2   receiving status messages via an optical channel, whereby the upstream node  
3   communicates said second set of optical characteristics as a status message via an optical  
4   fiber.

1        10.    An optical node for an optical network, the node comprising:

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2 at least one input port for receiving an optical datastream having a plurality of  
3 channels;  
4 a plurality of output ports for communicating the data stream to at least one other  
5 node via at least one optical fiber link;  
6 a line switcher arranged to select an optical pathway for the data stream between  
7 two of the ports of the node in response to a line switch command;  
8 a demultiplexing stage arranged to select at least one channel from said  
9 datastream, said stage including at least one redundant electro-optic element configured  
10 to replace a defective electro-optic element of said stage in response to an equipment  
11 switch command;  
12 at least one optical sensor configured to measure a first set of optical  
13 characteristics of the channels;  
14 a signal sensor for receiving data from an upstream device on a second set of  
15 optical characteristics of the channels upstream of the node; and  
16 a local controller configured to generate the switch commands, the local controller  
17 comparing said first and said second set of optical characteristics to detect a loss of signal  
18 in one or more of the channels, the controller initiating a line switch to isolate a line fault  
19 or an equipment switch to isolate an equipment fault.

1 11. The node of Claim 10, wherein said local controller comprises a micro-  
2 processor having a software program residing on said micro-processor for generating the  
3 line switch commands and the equipment switch commands, the software program  
4 comparing said first and said second set of optical characteristics against a problem list to





11 a loss of signal in one or more of the channels, the controller initiating a line switch to  
12 isolate a line fault or an equipment switch to isolate an equipment fault

1 19. An optical node for a wavelength division multiplexing optical network  
2 having an optical datastream with a plurality of optical channels, the node comprising:

3 a transport module, including:

4 a first primary fiber interface port;

5 a second primary fiber interface port;

6 a first secondary fiber port;

7 a second secondary fiber port;

8 at least one input having an optical sensor;

9 at least one output having an optical sensor;

10 at least one transceiver for communicating network channel status  
11 information with at least one neighboring node via an inter-node optical communications  
12 channel; and

13 a line switcher arranged to select an optical pathway between two of said  
14 ports in response to a line switch command;

15 a channel selection module optically coupled to said transport module, said  
16 channel selection module including:

17 a first filter stage containing a demultiplexor element arranged to select a  
18 band of channels from said transport module;

19 a second filter stage coupled to the first stage and arranged to select one  
20 of the channels of said band of channels;

21                   at least one redundant electro-optic element configured to replace a  
22   defective electro-optic element of said first stage in response to an equipment switch  
23   command; and

24 at least one optical sensor coupled to the second stage;

25 a tributary module coupled to transport module, said multiplex module containing  
26 at least one transponder for linking data from a selected optical channel to at least one  
27 channel of an external tributary network ; and

28           a control module configured to generate the switch commands, wherein the  
29   control module correlates the optical characteristics of the channels measured at the node  
30   with the channel status information received from at least one other node to determine if  
31   the node should initiate a line switch or an equipment switch.

1            20.    A wavelength division multiplexing optical network, comprising:

2 a first node containing a first optical sensor, a first transceiver for receiving and  
3 transmitting data on an inter-node channel, and a first local microprocessor for  
4 controlling a first line switcher and a first set of redundant electrical elements, the first  
5 local microprocessor transmitting a first status report on the optical characteristics of the  
6 channels in said first node via said first transceiver;

7 a second node containing a second optical sensor, a second transceiver for  
8 receiving and transmitting data on the inter-node channel, and a second local  
9 microprocessor for controlling a second line switcher and a second set of redundant  
10 electrical elements, the second local microprocessor transmitting a second status report  
11 on the optical characteristics of the channels in said second node via said second  
12 transceiver;





18 a first primary optical fiber line linking said first and said second nodes;  
19 a first protection optical fiber line linking said first and said second nodes;  
20 a second primary optical fiber line linking said second and third nodes;  
21 a second protection optical fiber line linking said second and third nodes; and  
22 at least one additional optical element linking said nodes into an optical ring;  
23 wherein each of the microprocessors determines whether to perform a line switch  
24 or an equipment switch in the node which it resides as a function of the optical  
25 characteristics sensed at the local node and the status reports received from the other  
26 nodes.

22. A method of fault detection and isolation in a node of an optical network having a datastream with a plurality of optical channels, the network including a plurality of nodes coupled to each neighboring node, each node having at least one local optical sensor, each node having at least one optical transceiver for communicating status reports to each neighboring node that it is optically coupled to, and each node having a local controller for controlling a local line switcher residing in the node, the method comprising the steps of:

8       sensing a loss in signal from a neighboring node via the local optical sensor;  
9       monitoring the transceiver to determine if the neighboring node is communicating  
10      status reports to the node; and

11 initiating a line switch to redirect traffic to an alternate optical path to restore data  
12 traffic if there is a loss in signal from the neighboring node and status reports are not  
13 being receiving from the neighboring node.

1            23.    The method of Claim 22, further comprising the steps of:

2        waiting a preselected period of time to verify a loss of signal; and  
3        initiating a line switch in the node unless a status report is received within the  
4        preselected time.

24. A method of fault detection and isolation in a node of an optical network having an optical datastream with a plurality of channels, the network including a plurality of nodes optically coupled to each neighboring node, each node having at least one local optical sensor, at least one transceiver for communicating data to each neighboring node that it is coupled to, and a local controller for controlling redundant elements residing in the node, the method comprising the steps of:

7       sensing a first set of optical characteristics of the optical channels traversing the  
8    node;

9 receiving status reports that include a second set of optical characteristics of the  
10 optical channels measured by at least one sensor in another node of the network;

11 comparing the first and second set of optical characteristics;

12 determining if one or more optical channels are being dropped in the node; and

13       initiating an equipment switch in the local node to restore the dropped traffic.

1            25.    The method of Claim 24, wherein the second set of optical characteristics  
2    are measured upstream of the node.

1           26.     The method of Claim 25, wherein each upstream node includes optical  
2     sensors and the second set of optical characteristics is measured using the optical sensors  
3     of the upstream nodes.

1            27.    The method of Claim 26, wherein the second set of optical characteristics  
2    include a channel map of active channels in the network.

28. A method of fault detection and isolation in a node of a wavelength division multiplexing optical network comprising a plurality of nodes coupled to each neighboring node by at least two fibers, each node having at least one local optical sensor for each channel linked to a local tributary network, at least one transceiver for communicating data to each neighboring node that it is coupled to, and a local microprocessor for controlling a local line switcher and redundant demultiplexing elements residing in the node, the method comprising the steps of:

8       sensing the optical power characteristics of all of the optical channels traversing  
9   the node;

10       sensing the optical power characteristics of each channel linked to the local  
11       tributary network;

12 receiving reports on the optical characteristics of the optical channels in  
13 neighboring upstream nodes;

14        updating a status list of measured channel characteristics in the node and in  
15        neighboring upstream nodes; and

16 determining if the power level of one of the channels drops below a  
17 predetermined level;

18       waiting a preselected period of time to receive a status update from the upstream  
19   nodes; and







